

Electronic Safe and Armed Fuzing (ESAF) Monitor

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LONG-TERM GOALS

The long-term goal of this program is to develop a technology to allow EOD technicians to interrogate an electronically safe and armed munition and determine the electrical status of these devices. Determining the electrical status of the mechanism will provide EOD technicians additional options to consider when determining the appropriate render safe procedure to use against these threat devices.

OBJECTIVES

The objective of this project is to investigate various technologies to quantify the electrical characteristics of Electronic Safe and Armed Fuzing (ESAF) ordnance devices and analyze these characteristics to determine if they can be exploited to ascertain the electrical status of ESAFs.

APPROACH

Our approach is to investigate the potential of both active and passive electromagnetic techniques for determining the electrical status of ESA munitions.

For passive detection approaches, we have developed a SQUID (superconducting quantum interference device) based testing system to determine if extremely low magnetic fields can be reliably measured from ESA devices without being overwhelmed by noise from the environment and the earth's magnetic field. The SQUID was chosen for a laboratory setup in an attempt to measure very low signals from

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active circuit components, such as timers and wires, less than 1 microamp. The SQUID has a sensitivity of at least 7 orders of magnitude (70 db) below ambient sources (the earth's dc magnetic field is about 120 db above the SQUID's sensitivity). A balanced second order gradiometer was built to help minimize the effects of noise in a spatially uniform magnetic field. The SQUID itself is difficult to field because of the requirement for liquid helium. Other more practical and deployable magnetic field measuring technologies should be explored to replace the SQUID if we are successful in making these measurements.

To investigate active detection approaches, we used a homodyne radar technique to analyze reflected signals and determine the electrical activity from ESAF devices. This technique radiates the device at a fundamental frequency around 1 Ghz and receives the fundamental plus the modulated signal from the ESAF. Detectable signal sources inside of the ESAF can include clocks and counters. The received modulated data could establish the status of the device being tested by detecting the activity of these components.

WORK COMPLETED

Test beds have been developed and continuously improved for data collection of active and passive electromagnetic experiments against ESA fuzes. In the laboratory, it was established that ESAF devices generate sufficient magnetic fields to be measured passively by SQUID technology and that the signal data collected can be used to determine the ESAF status. The problem attempted to overcome was in developing noise cancellation techniques so that environmental and man-made noise did not overwhelm our signal. This year's effort concentrated on all the sources of noise interference to determine what improvement could be achieved. Towards this goal efforts were concentrated in the following areas:

1. The S/N ratio of the SQUID has been improved by about 60 db through gradiometer balancing methods for unshielded operation in ambient fields.
2. Signal processing and improved measurement techniques were investigated in an attempt to significantly improve the S/N ratio of the SQUID sensor data.
3. Techniques for determination of ESAF device status using the homodyne radar approach were evaluated. Several ESAF devices were tested and data collected.

RESULTS

Due to the high sensitivity at DC and RF frequencies, the SQUID was recognized as a possible detection instrument for highly sensitive magnetic fields. Our previous work had determined that a SQUID sensor has the sensitivity to detect ESA magnetic fields in a controlled, laboratory environment. However, a major improvement in the S/N ratio is needed to make feasible the use of passive magnetic field measurements. Detection of magnetic fields associated with ESA fuzes with active magnetometers was relatively straightforward. In a laboratory setting, detection of low-frequency clock signals associated with an electric timer was accomplished at close range with signal acquisition times of several minutes. For detection of ESA fuzes without active magnetometers, we had hoped to detect the presence of magnetic fields associated with a DC current flowing within the ESA device. This was accomplished in a laboratory setting at a close range of several millimeters and with signal acquisition times of several minutes.

The major problem we were not sufficiently able to overcome was environmental noise. Although some of these noise issues can be managed and attenuated to some degree, there are magnetic noise sources that will greatly override signals from ESAs. These other noise sources, such as the effects of magnetic materials and 60 Hz current from powerlines, are not effectively canceled by gradiometers and signal processing. A slight vibration of the SQUID probe will tilt the coils off their perpendicular axis to the earth's field resulting in substantial field changes per microradian of tilt. Any vibration in the measurement area has a dramatic effect on measurements.

Even in the laboratory, the ESA fuze signal levels are too small to be detected with a wide bandwidth sensor. A wideband sweep generates little perceptible change in the magnetic field measurement. For the devices we were testing, we knew by probing the circuit what signal frequencies to look for. Without knowing exactly what frequency to measure, it would be time consuming to determine the ESA fuze status. This limits the effectiveness of the technique versus unknown items.

We have concluded that magnetic field measurements cannot reasonably be made in real life EOD scenarios because the environmental and the earth's magnetic field interfere with our ability to detect the magnetic fields from ESA devices.

For the active approach, using a homodyne radar technique, ESAF devices with time varying signal such as a timer or safe separation clock could be detected. For FY99 we will continue using this technique to quantify the limitations to this technique and work towards developing a test bed so we can perform evaluations outside of the laboratory.

IMPACT/APPLICATIONS

The impact for system applications is the advancement of detection capabilities using a combination of a non-SQUID based commercial magnetic field detector against ESAFs with active magnetometers and homodyne radar type systems to use against ESAF with active timing circuits. The technologies developed in this program will have an impact on bomb searches, low current surveillance devices and other electronic threats in various tactical situations.

TRANSITIONS

This program addresses the Electronic Energy Sensing Device Notional Concept. Once a proof-of-concept prototype unit has been developed, tested and proven effective, the program will transition to a Joint Service EOD acquisition effort. Technology will be transitioned to the development of improved EOD electronic detection devices during the life of the program.

RELATED PROJECTS

The EOD Applied Research effort has a standoff detection program that is investigating the use of SQUIDs for detection of buried metallic and non-metallic ordnance. As part of the standoff detection effort, a system model is being developed. Forward and inverse modeling will be accomplished to simplify interpretation of the spatial and temporal signatures. A synthetic database will be developed to simulate detector performance for different sensor designs and targets. Signal processing and UXO

target inversion algorithms will be demonstrated using the synthetic database. There is some synergy here that may be exploited. Both programs require substantial signal processing of SQUID sensor data. The efforts will be coordinated.

REFERENCES

W.J. DeHope, 1998: "Determining the Electrical Status of ESAFs Using Magnetic Field Measurements," *Maxwell Physics International*, October.